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## GREENHOUSE TOMATOES



**T**OMATOES GROWN IN GREENHOUSES near the markets can be ripened on the plants and put into the consumers' hands within a few hours of the time they are picked.

The quality of greenhouse tomatoes is far superior to that of the outdoor-grown crop competing with it, which is usually picked green and shipped long distances before reaching the markets.

Successful production in greenhouses requires the use of suitable structures with adequate heating and other equipment, good seed of suitable varieties, fertile well-adapted soil, and painstaking care in growing the plants and in handling the crop.

The greenhouse operator who can provide the high-grade equipment necessary and give the crop the care it demands is likely to find an increasing market for his product.

# GREENHOUSE TOMATOES

By JAMES H. BEATTIE, *Associate Horticulturist, Office of Horticultural Investigations, Bureau of Plant Industry*

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## INTRODUCTION

THE COMMERCIAL PRODUCTION of tomatoes in greenhouses in the United States is a development of the past quarter of a century. Previous to about 1900 little attention was paid to the forcing of the crop in glasshouses, the present importance of which is a marked tribute to the excellence of the product and the success of vegetable-greenhouse men in working out methods for handling this, the most difficult of the important vegetable forcing crops. Lettuce, cucumbers, and tomatoes constitute perhaps 90 per cent of the products of the vegetable-forcing ranges throughout the United States. Some ranges devote their energies to lettuce and cucumbers, but most of them grow tomatoes at some time during the year.

According to the 1919 census, the value of the vegetable crops grown in greenhouses aggregated \$15,487,878, almost every State in the Union being represented as a producer. Nearly \$14,000,000 worth of the products came from the New England, Middle Atlantic, East North-Central, and West North-Central States. Climatic conditions largely account for the absence of the industry in the South Atlantic, Gulf Coast, and Southwestern States, where it is usually possible to produce a long list of fresh vegetables as outdoor crops over the greater part of the year, and these sections also are accessible to tropical centers where year-round production of certain vegetables is possible.

Greenhouse ranges devoted to the tomato crop are to be found throughout the States where the industry has attained its greatest importance. Arlington, Mass., and Grand Rapids, Mich., are the two oldest important forcing centers. Large greenhouse ranges are to be found around Rochester, N. Y.; Philadelphia, Pa.; Ashtabula,

Cleveland, Toledo, and Columbus, Ohio; Chicago, Ill.; and other points. Suitable soil, ample labor, cheap fuel, and good transportation facilities have been contributing factors in the development of the industry in many sections.

When ripened on the vine, greenhouse tomatoes are far superior in quality to those grown outdoors in warm sections, where it is necessary to pick the fruit green in order to get it into the hands of the distant consumer without undue loss. Tomatoes marketed during the winter and early-spring months when prices are high are usually served as a salad or as an ingredient of a salad. A comparatively small quantity is ample for several persons; hence the vegetable is as economical to the housewife as other available salad crops.

The greenhouse owner must make a large investment in houses and equipment, and he must be prepared to spend large sums for the maintenance of conditions suitable for this exacting crop. On the



FIG. 1.—A large greenhouse devoted to a crop of tomatoes. The plants are trained to slender stakes set in the ground near them and supported by wires attached to the frame of the structure

other hand, a grower 2,000 or more miles from the markets must spend large sums for picking, packing, transportation, and handling before his crop can be realized upon. The products of properly located greenhouse ranges where fuel, labor, and other essentials can be obtained economically are usually able to compete successfully with tomatoes grown at distant points out of doors. The vegetable-forcing industry is increasing in importance, and the tomato is receiving its full share of attention.

## GREENHOUSES

A forcing house for tomatoes must be suitable for the exacting requirements of the crop. It must be of such construction that the least possible interference is offered to the entrance of light. It must be fitted with a ventilating system that permits the changing of the air without drafts, and it must have a heating system capable

of maintaining a sufficiently high and uniform temperature. A house containing a large volume of air is usually less subject to sudden fluctuations in temperature than a small house. Moreover, a high house with the ventilators several feet above the plants usually makes it possible to ventilate without drafts striking the plants. The house must have sufficient headroom for the plants, but structures meeting the other important requirements usually have an abundance of such room for tomatoes.

Detached houses 60 to 80 feet wide and 500 to 600 feet long (fig. 1) are largely used. The ridge-and-furrow type, with high gutters, is widely used for tomatoes. These houses are built in widths up to about 40 feet without inside posts, a steel truss supporting the roof in the wider ones. Three of these houses may be made to inclose a space 100 or more feet in width having only two outside walls, two inside gutters, and two rows of inside posts, each row being



FIG. 2.—Greenhouse tomatoes on raised benches. The plants are trimmed to a single stem and trained to strings tied to the roof of the greenhouse

directly beneath and supporting a gutter. The inside gutters cast some shade on the crop, but if they are sufficiently high this objection is negligible. The present tendency is toward large houses with high side walls of sash-bar and glass construction and with roofs so high that the glass is at a considerable distance from the plants. Whether the house is a large detached pipe-frame or steel-frame structure or consists of a number of ridge-and-furrow houses with high side walls so constructed that there is the least possible interference with the admission of light seems to be immaterial so long as the structure fulfills the requirements of this very particular crop.

#### BENCHES COMPARED WITH GROUND BEDS

During the early days of the industry practically all tomato growers believed that raised benches and bottom heat were essential to success with the crop (fig. 2). It was soon found that good crops

of tomatoes could be produced in houses without raised benches where the space was treated as an inclosed area to be handled in much the same manner as intensively conducted outdoor operations. Benches are still used to a limited extent in tomato houses, but in houses of newer construction there is a growing tendency to dispense with them.

Many growers believe that tomatoes grown on benches require several days less time to come into bearing than those planted in ground beds. Bottom heat from pipes located under the benches, better aeration of the soil on the benches, and better drainage all contribute to the earliness of the bench crop. Provision for adequate drainage, care in watering, and the use of temporary heating lines laid on the surface of the soil during the early stages of growth make it possible to secure earliness equal to that of the crop planted in ground beds. Benches are very expensive, and the cost of maintenance is often high. They bring the plants near the glass,



FIG. 3.—Tomatoes growing in a house where the plants are set and handled in much the same manner as where the crop is grown intensively outdoors. The concrete curbs are used to keep the soil out of the cluder walks

where they are more subject to fluctuations in temperature and more difficult to cultivate, trim, and train. Moreover, the tomatoes are difficult to gather when grown on raised benches. Under present methods of culture the natural ground beds are often plowed with a team or tractor, and the cost of applying the manure and preparing the soil is much less than when the work is done by hand on raised benches. The thin layer of soil usually employed on raised benches must, as a rule, be changed every year, but with ground benches such a procedure can usually be avoided. The ideal tomato house is a small field under glass where temperature, moisture, and other suitable growing conditions can be maintained (fig. 3).

#### WALKS

Concrete walks are considered an essential part of the modern vegetable house, since they serve as tracks for wheelbarrows or trucks used in handling the crop. However, the space occupied by walks

is involved in heat and maintenance costs, and therefore only absolutely necessary walks should be installed. Figure 1 shows the interior of a large house with concrete walks along each side. This is an excellent arrangement, as it is impossible to grow tomatoes near the heating pipes, where they would be subjected to excessive heat and also to drafts from the side ventilators. The house shown has but two permanent walks, with temporary board runways between the rows of plants. Interior walks are sometimes placed in line with interior rows of posts, but these interfere with the use of the walks for trucks, wheelbarrows, etc. In ridge-and-furrow houses narrow walks are nearly always placed under the gutters and around the posts. Although they do not serve as tracks for conveyances used in handling the crop, they occupy space not well suited to the crops and leave the remaining area in the house unobstructed. An occasional crosswalk is sufficient for crop-handling purposes.

### HEATING

The heating system employed must be capable of maintaining a uniform temperature, as sudden fluctuations are very injurious to the crop. A gradual change from about 60° F. at night to 70° or 85° F. during the day is permissible, but hourly fluctuation either day or night will usually prove harmful to the crop. The hot-water system, using either forced or gravity circulation, and vacuum and low-pressure steam systems give good results. Gravity-circulation hot-water systems are well suited to houses of moderate size. The rate of circulation is slow, necessitating the use of more radiation than is needed with certain forced-circulation or steam systems. Moreover, this type of system is not particularly adapted for use in very large houses. In small plants, where the care that can be given the boiler is usually limited, hot water is especially suitable, as the large volume of water in the system cools slowly, making frequent attention unnecessary. Forced-circulation hot-water systems are in satisfactory use in many plants. A pump of suitable type is used to hasten circulation, and in some cases the system is so arranged that entire dependence is placed on the pump for circulating the water. Vacuum and low-pressure systems require less radiation than is necessary for hot-water systems. They are very satisfactory, being particularly adapted to large houses and to ranges where the boilers have regular attention.

The size and arrangement of the piping in a tomato greenhouse are determined by the kind of heating system employed and by the size and construction of the house. Although overhead piping casts some shade on the developing crop, it is generally believed that at least a part of the radiation should be overhead, as pipes so located temper the air entering through the top ventilators and prevent cold drafts from striking the plants (see fig. 1). For the same reason it is desirable that part of the radiation be placed on the side walls. The current of warm air rising from pipes so placed prevents cold air entering through the walls and roof from striking the plants. The crop is safely blanketed under a canopy of warm air through which cold drafts are not liable to penetrate. The gable ends of large houses are usually supplied with banks of pipe to cut off the cold air from these large exposed surfaces.

Hot-water or steam heating systems can readily be adapted to such an arrangement of the pipes. The flow pipes are usually placed overhead at a higher level than the coils, with the whole system graded so that it slopes gradually downward to the boiler. With narrow ridge-and-furrow houses the radiating pipes are usually placed on the posts supporting the gutters, but in wider houses of this type at least a part of the radiation is placed overhead.

Table 1 shows the radiation needed to maintain temperatures suitable for tomatoes.

TABLE 1.—*Temperatures to be maintained and length of pipe of different sizes needed to supply radiation for gravity-circulation hot-water systems*

[Steam-heating systems take three-fifths of the length of pipe here stated]

Temperatures to be maintained	Radiation for each 1,000 square feet of glass or its equivalent <sup>1</sup> (square feet)	Length of pipe required to supply this radiation (feet)		
		1½-inch size	1¾-inch size	2-inch size
60° to 65° F.....	401	920	801	641
65° to 70° F.....	460	1,057	921	737
70° to 75° F.....	583	1,339	1,166	933

<sup>1</sup> By the term "equivalent" is meant the side walls of wood or masonry construction; 4 square feet of exposed surface of this character is figured as needing the same radiation as 1 square foot of exposed glass surface.

The exact amount of radiation to be installed can be determined only after giving consideration to such factors as geographical location, tightness of houses, exposure, and efficiency of the heating plant. In sections where low temperatures prevail or occur at intervals it is necessary to install more radiation than that shown in the table. The figures given are for an outside temperature of 0° F. Where lower temperatures occur the amount of radiation should be increased at least 1 per cent for each degree below zero. Thus, in sections where the temperature occasionally falls to -20° F., 20 per cent more radiation should be installed. Greenhouses in very exposed positions should have additional radiation, especially on the side from which the prevailing winds come.

#### VENTILATORS

Greenhouses for tomato growing usually have ventilators along the side just below the eaves and along both sides of the ridge. Side ventilators are often hinged just below the eaves and operated by machines attached to the side posts of the structure. Top ventilators are generally hinged to a member just under the ridge cap. Unless opened very wide such an arrangement allows water to drop from the ventilators to the roof. The overhanging ridge cap makes a water-tight joint. Machines for operating the top ventilators are placed on posts or pedestals at suitable intervals and within easy reach of the operator. Extreme care in securing tight-fitting easy-operating ventilators prevents drafts and aids materially in obtaining good crops.

## WATER SYSTEMS

Water pipes are usually placed under the beds and fitted with enough faucets so that any part of the house can be reached with 50 to 75 feet of hose. When the application of water is to be made entirely with a hose no additional equipment is necessary.

Subirrigation systems composed of lines of tile spaced from 2 to 4 feet apart and buried in the soil sufficiently to be out of the way of tillage tools make it possible to water the crop without packing the surface or wetting the foliage. The size of the tile, the distance between the rows, and the depth the tile is buried are determined largely by the character of the soil. Very tenacious or impervious soils, where the lateral movement of the water is slow, require the installation of lines of tile nearer together than is necessary with lighter soils. The lines of tile are provided with openings every 100 to 150 feet, so that the end of a hose can be inserted; and the water is run into the tiles until they are filled or the soil sufficiently moistened, when the hose is moved to the next line. This system insures against overwatering, as the lines of tile serve as drains also, and much benefit is secured by the aeration of the soil. Greenhouse-vegetable growers could well devote more attention to the subirrigation method of applying water.

Overhead sprinkler systems are extensively employed during the early stages of the crop, or until about the time that the blossoms appear; but they have not met with much favor for growing tomatoes, because wetting the foliage creates greenhouse conditions favorable to the development of certain diseases and unfavorable for the ripening and transfer of pollen.

## CROPPING PLANS

Tomatoes are seldom grown as a midwinter greenhouse crop. They are usually produced during the fall and early winter or as a spring crop. Few vegetable growers produce tomatoes alone, experience having proved that it is better practice to follow a definite greenhouse rotation, including two or more of the important forcing crops. No definite cropping plan suited to the needs of growers located in the various sections can be given. The rotations here suggested are followed very closely by many growers in the important forcing sections of New York, Pennsylvania, Ohio, Michigan, and elsewhere.

*Plan 1*

*Tomatoes.*—Seed sown July 1 to 15. Plants set in houses August 15 to 30. Vines removed December 15 to 30.

*Lettuce.*—Seed sown November 15 to 30. Plants set in houses December 15 to 31. Crop harvested March 15 to 31.

*Cucumbers.*—Seed sown February 1 to 15. Plants set in houses April 1 to 15. Vines removed July 1 to 15.

*Plan 2*

*Tomatoes.*—Seed sown July 1 to 15. Plants set in houses August 15 to 30. Vines removed December 15 to 30.

*Lettuce.*—Seed sown November 15 to 30. Plants set in houses December 15 to 31. Crop harvested March 15 to 31.

*Lettuce.*—Seed sown February 1 to 28. Plants set in houses March 15 to 31. Crop harvested June 1 to 15.

## Plan 3

*Lettuce*.—Seed sown August 1 to 15. Plants set in houses September 1 to 15. Crop harvested November 15 to 30.

*Lettuce*.—Seed sown October 15 to 30. Plants set in houses November 15 to 30. Crop harvested February 1 to 28.

*Tomatoes*.—Seed sown January 1 to 15. Plants set in houses March 1 to 15. Vines removed to make room for following crops when no longer productive.

Plan 3 is sometimes modified by growing fall tomatoes instead of the first crop of lettuce. The dates given are approximate, as crops are usually set over a period of two or three weeks, and the date of harvesting is determined to a certain extent by weather and other conditions. The greenhouse operator is anxious to have a steady supply for his markets and plans the setting of his crops to give him such a supply.

Fall-grown tomatoes do not as a rule yield such heavy crops as those ripening during early spring, when weather conditions are much more favorable.

Greenhouse tomatoes, during the early stages of their growth, do not fully occupy the space in which they are planted. (See fig. 1.) Some growers plant quick-maturing crops, such as radishes, beets for greens, and lettuce, between the tomato rows, removing these before the tomatoes require the space. Conditions are maintained according to the needs of the tomatoes; and although not ideal for cool crops like radishes and lettuce returns are often sufficient to cover the expense of bringing the tomatoes well toward the producing stage. Each grower should determine for himself which, if any, crop should be used as a catch crop with tomatoes; sometimes it may prove best to dispense with catch crops altogether.

## SOILS

Tomatoes are grown on a wide range of soil types. They are successfully produced upon soils varying from heavy clays to light sands. Light soils are easier to work and ordinarily bring the crop into bearing somewhat sooner than do heavier soils. When the crop is grown on benches where soil only a few inches deep is used, it is usually changed each year. This practice permits the choice of a soil of loamy character made, if possible, of sods from an old pasture the soil of which is a rather light clay loam or a heavy sandy loam. With this should be mixed about one-fourth of its bulk of well-rotted stable manure, preferably cow manure. By composting these two materials several months before they are required for use, a very satisfactory soil for the forcing of tomatoes is produced.

An excellent soil may be prepared by composting fresh sod soil from an old pasture with one-fourth to one-third its volume of organic or muck soil. To be suitable for this use, the muck must be from a deposit that has been reclaimed and devoted for a few years to the growing of cultivated crops, such as corn, flax, hay, onions, and cabbage. It must contain at least 80 per cent of organic matter, and must not be acid, or contain over 40 per cent of moisture. It must, moreover, be high in plant food, containing at least 2.5 per cent of nitrogen and 0.5 per cent of both phosphoric acid and potash. Such humus can be obtained in many localities, but the

advisability of using it must be determined by its cost. If manure is abundant and cheap there would be little to gain in using the muck.

If the supply of manure is limited, soil, muck, and manure may be used together with excellent results. A compost made of 4 parts of old-pasture sod, 1 part of rotted cow manure, and 1 part of suitable muck will generally give excellent results and should be prepared in the manner usually followed. The mixture of the manure and muck often gives better results than is obtained from the use of the materials separately.

Manure, muck, or any of the composts just mentioned may be used in houses where the soil is not changed and where it is desirable to lighten heavy soils, add organic matter and plant food, or otherwise make the soil more suitable for the production of maximum yields of greenhouse crops. When following such rotations as those suggested on page 7, the application of the organic matter and much of the plant food takes place before planting the other crops included in the rotation, as tomatoes do not require the heavy fertilization essential to both lettuce and cucumbers.

#### SOIL PREPARATION

Although greenhouse conditions necessitate the following of methods in the preparation of the soil somewhat different from those commonly followed outdoors, the principles are the same. With the large forcing houses now in use it is often possible to employ teams or tractors for the plowing, disking, rolling, and other operations in the well-prepared soil necessary to successful greenhouse-tomato growing. In smaller houses without benches and in those fitted with raised benches handwork is depended upon. The preparation of greenhouse soils is fully discussed in *Farmers' Bulletins* Nos. 1320, "The Production of Cucumbers in Greenhouses," and 1418, "Lettuce Growing in Greenhouses."

#### PLANT FOOD

Soils well supplied with organic matter and plant food from such composts as those described on page 8 should require but little additional fertilization for the production of a good crop of greenhouse tomatoes; in fact, when tomatoes follow lettuce and cucumbers which have been heavily manured there is great danger that additional applications of manure may result in excessive vine growth at the expense of the fruit. When planting the various crops according to a plan whereby the tomatoes follow other crops, as in the case of the rotation suggested on page 8, it may be necessary to use more compost, manure, or commercial fertilizer on the tomatoes.

#### COMMERCIAL FERTILIZERS

Material containing a high percentage of nitrogen must be used with great caution, as an excess of nitrogen causes excessive vine growth and dropping of the blooms, with failure to bear satisfactory crops. With plentiful supplies of good manure or good compost but little additional nitrogen is needed as a rule. Phosphoric acid is very necessary to the tomato and may be used in liberal quan-

tities with profitable results. Either bone meal or acid phosphate is generally employed. Potash also is essential to the growth of greenhouse tomatoes and may be applied in the form of hardwood ashes, muriate of potash, or some other form of the element. It is difficult to make definite recommendations as to the quantity of commercial fertilizer that should be applied, as this depends largely upon the past treatment of the soil. When using fresh compost little additional fertilization should be necessary or desirable. With soils which have been heavily cropped, applications of a mixture containing 1 to 2 per cent of nitrogen, 8 per cent of phosphoric acid, and 4 to 6 per cent of potash at the rate of from 10 to 20 pounds to each 1,000 square feet of surface should be sufficient. The grower must be guided by his own conditions in using commercial fertilizer, and, if his greenhouse-tomato crop indicates the need for such plant food, it should be applied.

#### MANURE

The use of manure as an ingredient of the soil has already been discussed. Additional use is often made with profitable results by employing it as a mulch, and when obtainable at reasonable cost this use is to be recommended. Fine strawy manure is preferable for this purpose, as such material protects the soil from rapid drying and keeps it mellow. The plant food in the manure is made available to the plants by leaching. Well-decomposed peat and muck of suitable character can also be used to good advantage for the maintenance of a mulch around the plants.

#### LIME

Where needed to correct soil acidity or as an aid in improving the physical character of the soil, lime should be used before attempting to grow a crop of greenhouse tomatoes. Heavier soils are more likely to need lime, but in all cases an actual test is necessary. Generally applications of 30 to 50 pounds of ground hydrated lime per 1,000 square feet of ground will be sufficient.

#### VARIETIES AND SEED

The tomato has long been popular as a glasshouse crop in England, where a large number of special small-fruited forcing varieties have been developed. These so-called English varieties are largely grown in greenhouses in the United States, particularly in the eastern section of the country. Carters Sunrise, Stirling Castle, Comet, Duke of York, and Perfection are kinds extensively grown. All of these are characterized by a large number of tomatoes borne in each cluster. The title-page illustration shows a portion of a plant of Carters Sunrise, a sort having particular merit. American varieties of tomatoes are extensively used for forcing work, especially in the Middle West. Globe, Bonny Best, and Stone are varieties largely grown. The market demand influences the choice of type and variety for forcing work, as some sections prefer the smaller English type and other regions demand the larger American type. Work carried on at the Arlington Experiment Farm showed no

great difference in the yielding qualities of the English and the American tomatoes. Table 2 gives results obtained with several of these.

TABLE 2.—*Comparative yields of different varieties of tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va., August 17, 1917, to January 31, 1918*

Variety	Number of plants	Weight of tomatoes (pounds)		Variety	Number of plants	Weight of tomatoes (pounds)	
		Total	Per plant			Total	Per plant
Earliana.....	30	150.53	5.02	Carters Perfection.....	30	80.69	2.69
Burbank.....	30	141.82	4.72	Carters Comet.....	30	79.28	2.64
Bonny Best.....	30	86.92	2.90	Listers Perfection.....	30	60.21	2.01
Globe.....	30	80.94	2.70	Tresco.....	30	103.96	3.46
Ponderosa.....	30	115.47	3.85	Carters Duke of York.....	30	68.92	2.30
Carters Sunrise.....	30	106.25	3.54	Livingstons Comet.....	30	64.91	2.16

In this test the American large-fruited varieties gave a greater total yield and a larger yield per plant than most of the English varieties. Both Earliana and Burbank bore heavy crops of large irregular tomatoes. Of the American varieties the Bonny Best and Globe gave moderate yields of high-class tomatoes. In the autumn and winter of 1918 a similar test was conducted. The results of this are shown in Table 3.

TABLE 3.—*Comparative yields of different varieties of tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va., August 25, 1918, to January 7, 1919*

Variety	Number of plants	Weight of tomatoes			
		Total		Per plant	
		Pounds	Ounces	Pounds	Ounces
Globe.....	31	130	9	4	3½
Dwarf Champion.....	32	116	11	3	10½
Tresco.....	32	182	2	5	11
Stirling Castle.....	29	174	4	6	0
Listers Perfection.....	29	163	14	5	10½
Carters Comet.....	32	145	13	4	9
Duke of York.....	29	137	13	4	12
Comet (B).....	32	131	4	4	1½
Carters Sunrise.....	24	127	13	5	5
Carters Perfection.....	32	119	5	3	11½

The yields, especially those from some of the English varieties, were very good for a fall crop, lower yields being usually obtained from fall-grown greenhouse tomatoes than from the spring crop.

Seed of two varieties, Carters Sunrise and Stirling Castle, saved from selected plants grown in the greenhouse at the Arlington Experiment Farm, was used in 1920 for the production of a spring crop in the same house used for the previous work. The results of this test are given in Table 4.

TABLE 4.—Comparative yields of two varieties of English forcing tomatoes grown in the greenhouses at the Arlington Experiment Farm, Va.

[Seed sown February 9; set in house March 25; first ripe tomatoes June 23; last, August 13, 1920]

Variety	Number of plants	Weight of tomatoes			
		Total		Per plant	
		Pounds	Ounces	Pounds	Ounces
Carters Sunrise.....	47	450	7	9	9
Stirling Castle.....	46	419	7	9	1

The data in these tables are presented to show what occurred under the conditions found in the houses where this work was conducted. Globe and Bonny Best seemed to be the best all-round large varieties tested. Carters Sunrise, Stirling Castle, and Comet were apparently the best of the English forcing sorts. Many growers of greenhouse tomatoes maintain their own seed stocks, and in some cases these are as distinctive as the named commercial varieties. The greenhouse tomato readily lends itself to improvement by selection and crossing, and some growers pay considerable attention to building up and maintaining strains suited to their needs. The Irondequoit (N. Y.) greenhouse men have a select strain of an English forcing tomato which is maintained from year to year, the seed of which may be grown in the greenhouse or in the open. A large number of plants can be produced from a small quantity of seed, and the use of good seed of a variety and strain suited to the purpose to which it is to be devoted is recommended.

## STARTING AND GROWING PLANTS

Tomato growers usually grow their own plants. The practice gives them the assurance of a supply of stocky, vigorous plants of the variety and strain desired and makes it possible to set the plants in the houses without the risk of shock and injury incident to shipping. By growing and handling his own plants the grower is able to reduce the danger of introducing diseases, such as *Fusarium* wilt,<sup>1</sup> and nematodes.<sup>2</sup>

## QUANTITY OF SEED AND NUMBER OF PLANTS REQUIRED

There are over 8,000 tomato seeds to the ounce, and a very small quantity of good seed is required to start plants for a large area. It is always best to use sufficient seed to give an abundance of seedlings. In practice, seed of high vitality should give 2,000 to 3,000 first-class plants per ounce. It is a wise insurance to provide twice the number of plants needed to set the space to be devoted to the crop. Table 5 shows the actual number of plants needed to plant each 1,000 square feet of bed when spaced at varying distances.

<sup>1</sup> The wilt is due to the attacks at all stages of the development of the plant of *Fusarium lycopersici* Sacc.

<sup>2</sup> The gall-like swellings on the roots are caused by the attacks of an eelworm, *Heterodera radicum* (Greef) Müller.

TABLE 5.—*Tomato plants required to set each 1,000 square feet of bed when spaced at varying distances*

Distance between rows	Distance between plants in the row	Plants for each 1,000 square feet of bed space <sup>1</sup>	Distance between rows	Distance between plants in the row	Plants for each 1,000 square feet of bed space <sup>1</sup>
	<i>Ft. In.</i>	<i>Number</i>		<i>Ft. In.</i>	<i>Number</i>
2 feet.....	2 0	250	3 feet 9 inches.....	1 6	178
2 feet 6 inches.....	2 0	200	3 feet 9 inches.....	1 9	153
2 feet 9 inches.....	1 6	242	3 feet 9 inches.....	2 0	133
3 feet.....	1 3	267	4 feet.....	1 0	250
3 feet.....	1 6	222	4 feet.....	1 3	200
3 feet.....	1 9	190	4 feet.....	1 6	167
3 feet.....	2 0	167	4 feet.....	1 9	143
3 feet 3 inches.....	1 3	246	4 feet.....	2 0	125
3 feet 3 inches.....	1 6	205	4 feet 3 inches.....	1 0	235
3 feet 3 inches.....	1 9	176	4 feet 3 inches.....	1 3	188
3 feet 3 inches.....	2 0	154	4 feet 3 inches.....	1 6	157
3 feet 6 inches.....	1 3	229	4 feet 3 inches.....	1 9	134
3 feet 6 inches.....	1 6	190	4 feet 6 inches.....	1 0	222
3 feet 6 inches.....	1 9	163	4 feet 6 inches.....	1 3	178
3 feet 6 inches.....	2 0	143	4 feet 6 inches.....	1 6	148
3 feet 9 inches.....	1 3	213			

<sup>1</sup> The outside rows of plants are figured as occupying the edge of the area. Adjacent areas of equal size would require slightly fewer plants.

In producing tomato plants the methods followed are determined to a great extent by the season of the year during which the crop is to be grown. Plants for the fall crop are often produced outdoors in a place where they can receive the necessary attention. Cold-frames or hotbeds without heat are often used. The greenhouse is usually too hot during July and August for the production of good plants. For the spring crop most growers utilize a separate house where the tomato plants can be well protected and given the best of care.

#### SOIL FOR TOMATO SEEDLINGS

A soil of a friable character well supplied with organic matter is especially adapted to the production of tomato plants. When loam soils of the proper character are not available for the preparation of composts for the starting and growing of the plants, satisfactory results may be secured with other types provided they are modified through the use of muck, manure, sand, or in the case of light sands heavier soils to bring them to the proper physical, moisture-retaining, and plant-food-bearing condition. A compost made of 3 to 4 parts of bluegrass sod and 1 part of cattle manure is excellent. Such a compost should be prepared several months in advance of the time it will be needed and turned two or three times to insure a perfect mixture. It should be sufficiently decayed so that practically all the grass roots and vegetable matter in the manure have disappeared. At the final turning it should be screened to remove stones, lumps, or fibrous matter, and it is an excellent plan to add 2 to 4 pounds of ground bone to each ton of the compost.

Owing to the general prevalence of such diseases as *Rhizoctonia* and other damping-off fungi, which are liable to attack the seedlings, it is usually best to sterilize the soil. Sterilization can be effected by spreading the soil 6 or 8 inches deep on a concrete floor and

wetting it with a solution of formaldehyde, 1 part of the chemical to 99 parts of water, using a gallon of the mixture to each square foot of soil. Sterilization by steam can be effected by spreading the soil in the greenhouse or on a floor and using the inverted steam pan, as described in *Farmers' Bulletin 1320, The Production of Cucumbers in Greenhouses*. Another method consists in placing the soil in the flats to be used for growing the seedlings and putting these in a wooden or concrete cabinet fitted with pipes for the admission of live steam. The steam is turned on and the soil heated to about 212° F., this being accomplished as a rule in 30 to 45 minutes. The flats must be allowed to stand until sufficiently dry to permit handling the soil before the sowing is done.

The seed is usually sown in drills 2 to 3 inches apart. A convenient method for making the rows consists in pressing the edge of a plastering lath into the well-fined seed bed to a depth of half an inch, repeating the operation for adjoining rows. The seed should be uniformly distributed in these drills at the rate of about four to each inch and covered by filling the furrows with loose loam, leaf mold, muck, or a mixture of sand and soil. Whatever material is used it should be of a friable character, so that the seedlings can come through the surface without difficulty. It is desirable that the soil be kept in an ideal moisture condition. If too wet the seed may rot, and if too dry it will not germinate satisfactorily. It is often advisable to cover the bed with burlap until the seeds germinate, but when this is done care must be exercised to remove the burlap by the time the seedlings begin to come up. Temperatures ranging from 70° to 75° F. are satisfactory for the germination of tomato seed. After the seedlings are well up this may be reduced somewhat. Moderately low temperatures are favorable to the securing of stocky plants.

Tomato plants for the greenhouse crop are usually transplanted. The seedlings are ready for transplanting in from 10 days to 2 weeks after the seed is sown. They are sometimes moved to flats, where they are set from 2½ to 3½ inches apart and left there until moved into the house where the crop is to be grown. In other cases they are transplanted to paper pots or thumb pots and later shifted to larger pots, plant bands, or berry baskets. The farther the plants can be carried in the plant house without stunting them or allowing them to become rootbound or overcrowded and spindling, the less time will be required for securing the crop in the greenhouse. From 4 to 8 weeks are usually allowed for the production of the plants.

Outdoor-grown plants for the fall crop must be produced under prevailing temperature conditions. Excessively high temperatures can be partly overcome by shading the plant bed. Greenhouse-grown plants for the winter or spring crop are usually grown in a special house or in a part of one of the main houses. After the plants are up, a day temperature of 60° to 70° F. with a night temperature some 5 to 10 degrees lower is usually satisfactory. Good strong plants are essential to securing profitable yields of high quality.

## ESTABLISHING THE CROP IN GREENHOUSES

Plants for the fall crop are usually set during August or early in September. Many of the larger growers in the northern Ohio district aim to plant about August 15; and it is seldom desirable to defer fall planting much after September 1, as by so doing the crop comes into bearing during the shortest days of the year, when a minimum amount of light is available. March 1 is a favorite date for setting the plants for the spring crop, but the time varies to suit conditions. It is not desirable to set the plants until the coldest weather is over, as large quantities of fuel would be required to maintain the interior of the houses at a temperature suitable for satisfactory growth. Neither is it desirable to defer planting until the product would mature at a time when low-priced outdoor-grown tomatoes are available on the markets. Plants set about March 1 usually begin to produce ripe tomatoes late in May or early in June. Soil, temperature, weather, variety, cultivation, and many other factors affect the time of ripening.

### PLANTING DISTANCES

The width of the beds, type of house, and system of training to be followed must be taken into account in determining the planting distances. There is little to be gained by too close spacing, as this results in excessive shading and lowered yields per plant. Most of the large growers set the plants in rows 3 to 4½ feet apart with the plants from 12 to 18 inches apart in the rows, although all the planting distances given in Table 5 are used. Varieties having a small habit of growth may be placed closer together than those inclined to make a heavy growth.

### SETTING THE PLANTS

The soil should be given a final surface working just before the plants are set. The beds are usually laid off with a marker or with a garden line. Furrows about 6 inches deep are often made with a light tractor or with a horse-drawn plow. When the plants are being set such distances as would make possible the practice of cultivation in both directions it is very necessary that they be accurately "checked," so that the rows will be straight. This is usually done by using cross lines or in large houses by marking the ground in both directions.

Planting follows the usual practices adapted to this class of plants. Those grown in flats are cut apart, leaving as large a ball of soil and roots as possible on each plant, and set in position with the earth firmly packed about them. Plants grown in paper or wooden bands, berry boxes, or other containers are handled in much the same way. It is desirable that the band or berry box be removed when setting the plants, but with such care as to leave the root system intact. The freshly set plants are always watered, and if planted at a season when the sun is hot they should be moderately shaded for a few days.

## CULTIVATION

When proper preparation of the soil has been made, cultivation is limited to maintaining a surface mulch and the resultant control of weeds. Deep cultivation is undesirable and likely to be injurious to the root system of the plants. Hand tools, such as the hoe, scuffle hoe, and rake, are employed. Horse-drawn tools are not largely

used for the cultivation of greenhouse tomatoes. Some growers mulch the ground between the plants, using fine strawy manure, and give no cultivation after the mulch is applied.

TRIMMING  
AND TRAINING

The single-stem system of trimming and training is almost universally followed, although some growers train the vines to two and sometimes three stems. As the plants grow, the shoots arising between the leaves and the main stem are removed, so that the energy of the plant is thrown into the main stem. Trimming is usually continued until the plant reaches the top of its support as a single stem, after which it is limited to the removal of shoots appearing on the



FIG. 4.—Tomato plants trained to strings

main stalk and in the top of the plant, which usually tend to droop downward. Unless the plants are kept well pruned the foliage will interfere with the admission of sunlight and the development of ripe tomatoes. Some growers make a practice of removing about half of each leaf borne on the lower part of the plant, in order that the light will have better access to the plants.

Great caution must be exercised in trimming to avoid spreading such diseases as bacterial wilt<sup>3</sup> and mosaic, both of which may be readily transmitted from plant to plant by the pruning knife or by the hands. Plants showing symptoms of these diseases should be

<sup>3</sup> Caused by *Bacillus solanacearum* Erw. F. Smith.

passed by and trimmed later, when special precautions should be taken to prevent the further spread of the diseases. One of the most effective methods of preventing their spread is to sterilize the pruning knife and the hands in a 1 to 500 solution of corrosive sublimate after handling each suspected plant.

One method of supporting the plant consists in running a heavy twine from a small stake driven into the ground near the base of the plant or a coil-wire anchor twisted into the soil in the same location to an overhead attachment, such as a wire or rod secured to the frame of the greenhouse (fig. 4). The plant and the string are gently twisted together as growth proceeds, and an occasional tying

of the main stem of the plant to the string with soft twine or raffia is sufficient to give proper support. Figure 5 shows the interior of a house planted to tomatoes trained to a single stem and supported by stakes. These stakes or lathis, about half an inch thick and an inch wide, are set in the ground near the plant and tied to overhead wires or other supports, and they are extensively used. The plants are usually trimmed to a single stem, and tied every few inches to the stakes with a very soft twine or raffia. The best practice is to tie the string or raffia loosely around the plant just below



FIG. 5.—Tomato plants trained to stakes

a fruit cluster or a leaf and tightly to the stake. This method of tying the plants allows the stems to increase in size without being cut by the string, yet supports them when the weight of the tomatoes tends to pull them down (fig. 6). Still another method of training is illustrated in Figure 3. Horizontal wires borne by posts or stakes are used as supports for the plants, the main stem being loosely tied to each wire.

Some growers use a heavy wire attached to screw eyes set in the gutters of the house or to holes drilled in the angle-iron eaves plate of the house. In some cases a woven-wire device consisting of two parallel wires connected by diagonal wire is used, the whole being about an inch wide. The support for the strings and stakes must be strong and tight to prevent sagging. The weight of a house of

tomatoes in crop is considerable, and the house must be so constructed that it will support it. In case the greenhouse is not so designed that it can be safely used as attachment for the wires supporting the plants, it is advisable to install anchor posts of pipes or angle-iron construction to serve this purpose. Such anchors may be placed at the ends of the houses and spaced as much as 100 feet apart provided they are substantially constructed.

### TEMPERATURE AND VENTILATION

Day temperatures ranging from 70° to 85° F. are satisfactory for tomatoes. Night temperatures some 10 degrees lower are usually maintained. Sudden fluctuations as well as excessively low or abnormally high temperatures are extremely injurious to the crop. Success in the growing of greenhouse tomatoes requires the employment of houses capable of being maintained at the proper temperature even under the most unfavorable weather conditions.

Ventilation of the greenhouse-tomato crop is extremely important. The plants must be supplied with some fresh air even in very cold weather, and this must be accomplished without exposing them to drafts. Houses with the ventilators several feet above the plants and inclosing a large volume of air come nearest to meeting the requirements.

### POLLINATION

Artificial pollination is extremely important and may be accomplished by means of a watch glass and wand. The watch glass is held under the flowers, the stems of which are tapped with the wand. This dislodges the ripe pollen, which drops upon the watch glass; and the glass is then lifted sufficiently to cause the stigma of the flowers to dip into the pollen on the glass.

Most growers go through the houses and jar the supports bearing the plants, thus dislodging the pollen and causing it to come in contact with the stigmas of the blooms. Hand pollination or the jarring method can be accomplished only when the air in the green-



FIG. 6.—A well-trained plant of a special strain of Sunrise, a well-known forcing sort

house is dry and the temperature rather high, which is usually about the middle of a bright sunny day.

### WATERING

The tomato requires an abundance of water, but it must be applied with painstaking care. Most growers use a hose for the application of the water, and some employ the subirrigation method, using lines of 3 to 5 inch tile buried in the soil at close intervals, into which the water is run. This method avoids the objectionable puddling of the surface soil, which frequently follows the application of water by a hose or by flooding. Overhead irrigation systems seem to interfere with the ripening and distribution of the pollen.

Moderately frequent applications of water, which prevent the soil from drying out too much, are believed to be best. Excessive applications of water and poor ventilation, causing a damp atmosphere, are unfavorable to tomatoes. Careful management of the greenhouse, including the application of water, is essential to success with the crop.

### INSECT ENEMIES <sup>4</sup>

The commonest forms of insects which injure greenhouse tomatoes are the white fly, plant lice, and the red spider. The greenhouse leaf-tyer and the corn earworm may also gain access to the house but ordinarily pass unnoticed, although at times they may cause considerable damage.

#### GREENHOUSE WHITE FLY AND PLANT LICE

The presence of the white fly <sup>5</sup> in the greenhouse can be readily detected, as this small white insect usually takes flight when the plants are disturbed. The immature and adult forms develop and feed on the under sides of the leaves and obtain their food by sucking the plant juices. When the insects are abundant, this feeding causes the leaves to turn yellow and finally die.

The plant lice, or aphids, which usually attack tomatoes in the greenhouse are the spinach aphid <sup>6</sup> and the potato aphid. <sup>7</sup> These soft-bodied louselike insects feed on the under sides of the leaves and on the terminal shoots by sucking the plant juices. They develop rapidly, and unless checked serious damage may result.

#### CONTROL BY HYDROCYANIC-ACID GAS FUMIGATION

The cheapest and most effective method of controlling the white fly and plant lice in the greenhouse is by fumigation with hydrocyanic-acid gas. The gas is generated from sodium cyanid and, being very poisonous, may occasion serious injury to plants or human beings if care is not exercised in its use, although in careful hands and with a little practice this fumigant can be employed with excellent results. The grower who is interested in hydrocyanic-

<sup>4</sup> Prepared by W. H. White, Truck-Crop Insect Investigations, Bureau of Entomology.

<sup>5</sup> *Trialeurodes vaporariorum* Westw.

<sup>6</sup> *Myzus persicae* Sulz.

<sup>7</sup> *Macrosiphum solanifolii* Ashm.

acid gas fumigation may obtain full directions as to its proper use from the Bureau of Entomology, Department of Agriculture, Washington, D. C.

#### CONTROL BY NICOTINE FUMIGATION

Fumigation with nicotine is used extensively and with effective results for the control of plant lice, but the white fly is highly resistant, a heavy dosage being necessary to kill even the adults.

Nicotine for fumigation purposes is derived from several sources. The burning of tobacco stems is one of the oldest methods and is largely practiced in sections where the stems are readily obtained. The stems are burned in galvanized buckets or garbage cans, or placed in small heaps along the walks of the house. For even distribution of the material, place the containers or heaps at intervals of about 25 feet along the walks. Before burning, dip the stems in water for a moment and allow to drain. This will moisten them sufficiently to cause the material to burn slowly without flame and produce a dense, heavy smoke.

A more convenient method of fumigating with nicotine is by burning commercially prepared nicotine papers and nicotine fumigating dust.

Liquids containing "free" or volatile nicotine may be vaporized by applying the substance in a thin layer on a hot steam pipe by means of a paint brush or an oil can.

Tobacco stems and the commercial papers, fumigating dusts, and liquids containing volatile nicotine for fumigation contain variable amounts of nicotine, and it is, therefore, advisable to follow directions for their use as given by the manufacturer. The grower should carefully check results, and if the fumigation has not been effective the quantity of material used should be increased.

#### RED SPIDER

A small mite, commonly called the red spider,<sup>8</sup> varying in color from light green to red, is one of the most difficult pests to combat. When present in small numbers, it feeds on the under sides of the leaves, but as it increases it attacks the entire plant, oftentimes covering it with a fine web. This mite apparently thrives under dry conditions and is usually more abundant on plants which receive but little water on the foliage.

A close watch should be maintained for the first appearance of this pest in order that it may be checked and not allowed to spread over the entire house. A spray consisting of about 2 pounds of soap and one-eighth pint of nicotine sulphate to 10 gallons of water should be thoroughly applied to the infested plants. During this application every effort should be made actually to cover the body of the mite with the spray. Syringing the plants with water washes the pests from them, and as many of the mites are unable to return to the plant this treatment usually results in an effective control. When the plants are in flower, however, such applications may interfere with the proper development and distribution of the pollen and must be employed with caution.

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<sup>8</sup> *Tetranychus telarius* L.

## GREENHOUSE LEAF-TYER

The greenhouse leaf-tyer<sup>9</sup> occasionally becomes troublesome on tomatoes in the greenhouse. The moth deposits its eggs in masses on the under side of the leaf. The worms, or larvæ, which hatch from these eggs are, when full grown, about three-fourths inch long, green in color, and marked with dark longitudinal stripes.

The normal habit of the worms when they are feeding is to fasten together the leaves and feed on the under sides. When abundant, they may devour the entire leaf.

If the attack is confined to a few plants, hand picking is the most convenient means of destroying the insect. When the attack is general throughout the house, spray or dust with an arsenical. The habit of the insect of feeding on the under side of the leaf makes it essential that the poison be applied to that portion of the plants.

## CORN EARWORM

The corn earworm,<sup>10</sup> a common pest on corn, beans, and tomatoes in the field, sometimes develops in the greenhouse and may cause considerable damage in its feeding upon the fruit. Hand picking the worms will usually prove sufficient to hold this pest in check.

## DISEASES

Several diseases which attack the outdoor tomato crop seriously interfere with the production of greenhouse tomatoes. Greenhouse conditions are usually favorable to the development of serious diseases, which, if not controlled, will materially reduce the yield if not entirely destroy the crop.

DAMPING-OFF<sup>11</sup>

Several damping-off fungi are responsible for severe losses of plants. The attacks of these fungi are encouraged by crowding in the plant bed, lack of ventilation, too much moisture, and too high temperature. Such conditions make the seedlings an easy prey to the causal organisms, which, however, may be controlled by sterilizing the soil with steam, hot water, or formaldehyde. The use of fresh soil as a control measure is to be recommended, but its sterilization is also advisable.

FUSARIUM WILT<sup>12</sup>

Without extensive control measures Fusarium wilt would soon bring upon the grower severe reductions in yield, if not the destruction of his crop. The disease clogs the water-bearing cells and manifests itself by stunting in growth, yellowish lower leaves, and finally a wilting and slow dying of the entire plant. During the progress of the disease the stems become discolored and when cut across have a dark-brown color between the bark and the pith. The wilt is soil

<sup>9</sup> *Phlyctaenia rubigalis* Guen.

<sup>10</sup> *Heliothis obsoleta* Fab.

<sup>11</sup> Caused by *Rhizoctonia solani* Kuhn and *Pythium debaryanum*.

<sup>12</sup> Caused by *Fusarium lycopersici* Sacc.

borne, and the greenhouse man has two methods of controlling it. He may sterilize his soil with steam, hot water, or a formalin solution, or he may use wilt-resistant tomato varieties and strains. Obviously, there would be little gained by using fresh soil free from the disease unless the beds, walls, benches, and other parts of the greenhouse were sterilized. Sterilization of the soil and the beds with live steam is the control method most generally followed.

The use of wilt-resistant sorts in the open is now well established. The Office of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, has developed several wilt-resistant varieties, such as Marvel, Norton, and Norduke. When Norton and Norduke are used for forcing, the water supply should be somewhat restricted, especially until the plants have begun to set fruit.

#### ROOT-KNOT <sup>13</sup>

The attacks of minute eelworms give rise to swollen knots on the roots of the plants, causing a yellowing of the leaves and a stunting of the plants, with a heavy decrease in yield and sometimes even death. The development of these parasites is greatly retarded by soil temperatures of less than 60° F. Sterilization of the soil with steam during the summer months is regarded as the most effective control for this disease. The soil must be heated to a temperature of about 210° F. for a depth of at least a foot, as the eelworms penetrate to considerable depths. They work under concrete walks and even under the walls and are difficult to control. Nematodes present one of the most difficult problems the greenhouse tomato grower has to meet.

#### OTHER LESS IMPORTANT DISEASES

##### STEM-ROT <sup>14</sup>

Stem-rot manifests itself by the wilting of the outer leaflets, followed by complete wilting of the leaves and death of the plant. Although it is not common in greenhouses it sometimes causes considerable loss. The main stem rots near the ground, where it is usually covered with a moldlike growth. Inside the stem somewhat elongated hard black bodies (sclerotia) are usually formed. Steam sterilization of the soil is the standard remedy.

##### LEAF-MOLD <sup>15</sup>

Leaf-mold is one of the commonest diseases affecting greenhouse tomatoes and appears as velvety spots on the lower sides of the leaves. These become brown in color and the leaves may curl up. Greenhouse tomatoes are frequently attacked by this disease, especially where the conditions in the houses are not suitable for the crop. With the application of water by subirrigation and ample ventilation little trouble should be experienced from this disease.

<sup>13</sup> Caused by an eelworm, *Heterodera radiculicola* (Greef) Müller.

<sup>14</sup> Caused by *Sclerotinia libertiana* Fekl.

<sup>15</sup> Caused by *Cladosporium fulvum* Cke.

## MOSAIC

Mosaic manifests itself by an abnormal leaf development of the affected plant. The leaves sometimes take on a fern-leaved shape, and a variegated or mottled effect is frequently noticeable. A rosette appearance is also often apparent. Although yields are undoubtedly reduced by this trouble, as a rule it does not cause the death of affected plants. It is known to be transferable from one plant to others by knives and other implements and by insects. Affected plants should not be trimmed or handled at the same time as healthy ones. Insect control is an obvious necessity.

## BLOSSOM-END ROT

This disease sometimes causes serious losses to the greenhouse tomato crop. In its early stages it is characterized by yellowish spots around the dried blossom on the tomato, which enlarge and take on a dark color with a well-defined margin. The affected fruits are worthless, and as this rot is especially liable to attack the early portions of the crop the disease is an exceedingly destructive one. The exact cause of the trouble is not known, but it seems to be associated with drougthy conditions in the soil. The use of soil well supplied with organic matter and of high moisture-holding capacity is believed to minimize the injury from this trouble.

Many other diseases cause occasional losses in the greenhouse-tomato crop. For more complete information on the subject, write to the Bureau of Plant Industry, United States Department of Agriculture.

## HARVESTING AND HANDLING

Greenhouse tomatoes can usually be left on the plant until ripe and still be placed on the market and in the hands of the consumer in perfect condition. The high quality of a product handled with the dispatch possible with the greenhouse tomato adds materially to its popularity.

Most growers make a practice of gathering the tomatoes two or three times a week. Pickers use a basket or some other suitable container for transferring the product to the packing room, wheelbarrows or trucks running on the concrete walks usually being employed to expedite the handling of the crop. Most growers grade, sort, and pack according to size, quality, and market demands. The tomatoes are wrapped in tissue paper if to be shipped a considerable distance or to accord with market demands. Larger fruited sorts are usually wrapped singly, whereas the small forcing types are often wrapped three or four together.

Many kinds of packages are used. Some growers use a veneer basket, such as is shown in Figure 7, holding 10 pounds of wrapped tomatoes. The standard-bushel box is extensively used in the Boston, Mass., area. This box is  $17\frac{1}{2}$  inches square and  $7\frac{1}{8}$  inches deep, accommodating eight cardboard packages, each of which holds 6 pounds of tomatoes. The standard 4-quart cup, six of which are packed in a crate, is used by some growers. Corrugated-cardboard

boxes holding a few pounds and other kinds of containers are also employed. The particular kind selected is determined by the size of the tomatoes and by market demands.

#### YIELDS

Fall-grown tomatoes seldom yield as heavily as the spring crop, which is produced when conditions are more favorable. A yield of 4 pounds per plant is considered good for the fall crop. As much as 10 pounds per plant is sometimes secured in spring. Tables 2, 3, and 4 show yields secured with various varieties grown in the greenhouses at the Arlington Experiment Farm, Va. A grower in the Rochester, N. Y., area secured a yield of 5,000 pounds in a house

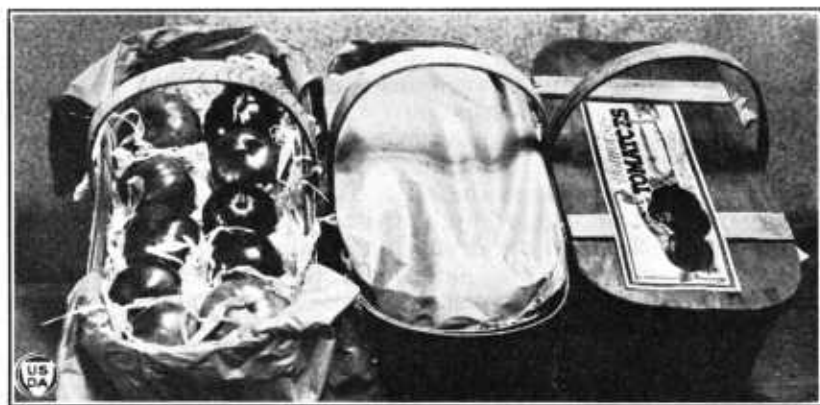


FIG. 7.—Ten-pound veneer baskets largely used for packing and marketing greenhouse tomatoes

about 30 by 180 feet. This yield is perhaps higher than could be expected under less favorable conditions.

#### RETURNS

Gross returns range from as low as 10 cents a pound to as high as 50 cents. The net returns depend on such factors as the amount of the investment in greenhouses and other equipment and the cost of fuel, labor, manure, fertilizer, packages, and other widely varying factors.

The public is rapidly learning to appreciate the superior qualities of greenhouse-grown tomatoes, which are more popular than the other prominent forcing crops but require great skill to produce. The requirements are now well understood by most greenhouse men, and it is probable that the industry could, with profit, be still farther expanded.